A RF-E-B-Dipole for Spin Manipulation at COSY

Permanent EDMs (**E**lectric **D**ipole **M**oments) of fundamental particles violate both time invariance and parity and thus, according to the *CPT* theorem, imply *CP* violation. The standard model prediction for the EDM gives unobservably small magnitudes, therefore any measurement of non-vanishing EDMs would be a signature of “new physics”.

EDM experiments with charged particles are only possible in storage rings. They incorporate measurements with horizontally polarized particles. To maximize the spin coherence time, systematic studies of unwanted spin rotations utilizing for instance a vertical RF–B field are required. To avoid simultaneous kicking of the beam in the transverse plane, the resulting *Lorentz* force needs to be compensated by the force of an orthogonal electric field, leading to a *Wien-Filter* configuration. This is realized at COSY in the form of a new RF-E-B-Dipole (see Figure 2). For deuterons at 970 MeV/c ($\beta = 0.459$) compensation occurs at an impedance of

$$Z = \frac{E_x}{H_y} = -\frac{E_y}{H_x} = Z_0\beta_z = 172.9\,\Omega.$$

The RF-B part consists of a 560 mm long coil made out of 6 mm copper tubes with 8 windings around a titanium coated, ceramic section of the beamchamber (see Figure 3).

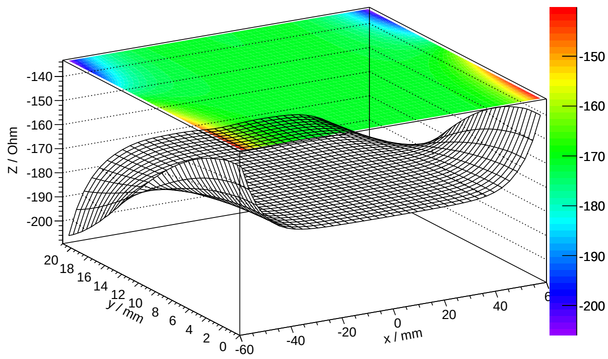

Figure 1: Simulation of the impedance distribution in the central field region.

The inductance is $L = 20\,\mu$H, this leads to a maximum magnetic flux in the horizontal plane of $\hat{B}_x = 0.40$ mT at a current amplitude of $\hat{I} = 10$ A. The integrated field along the beam axis is $\int \hat{B}_x\, \mathrm{d}l = 0.20$ T mm. Introduction of ferrites into this system will flatten the field distribution in the transverse plane, increase the inductance up to 70 µH and the maximum flux up to 0.59 mT at $\hat{I} = 10$ A. The integrated field along the beam axis will increase up to $\int \hat{B}_x\, \mathrm{d}l = 0.33$ T mm.

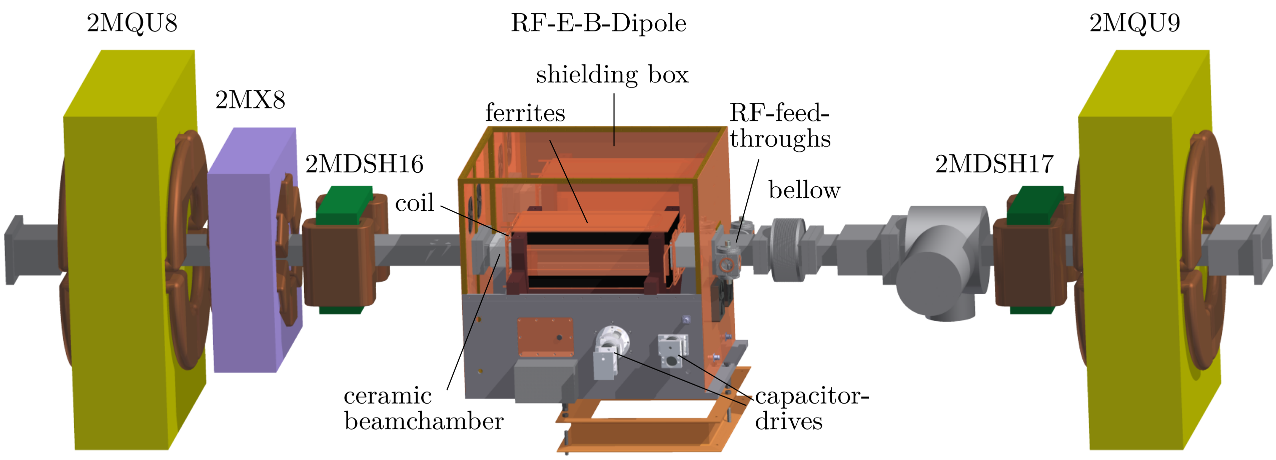

Figure 2: Location of the RF-E-B-Dipole inside a RF-shielding box in the arc of COSY.

Two stainless steel electrodes (AISI 316L) inside the vacuum chamber made out of 50 µm thin foil provide the electric field. Due to the large penetration depth of $\delta \approx 450\,\mu m$ in this material, the overall damping of the external magnetic field is negligible.The electrodes are spanned over glass rods held by a frame inside the flanges of the ceramic beam-chamber (see Figure 3). At an electrode distance of 54 mm, the required total potential difference between the electrodes is 4388 V.

The RF-Dipole is operated at the first few harmonics of the spin tune ($\gamma G + k$). Within the momentum range at COSY, this involves frequencies of 100 kHz to 2000 kHz. The RF-power is supplied by two separate frequency-generator and amplifier pairs. Adjustable capacitors (see Figure 2) together with the coil in case of the RF-B-Dipole and a 180°-phase-splitter between the electrodes in the case of the RF-E-Dipole form two parallel resonance-circuits. This provides the possibility of tuning the system to the required range of resonance frequencies while simultaneously matching the circuits' impedances to 50 Ω.

First successful tests of the RF-B-Dipole have already been undertaken during a beamtime of the JEDI collaboration (**J**ülich **E**lectric **D**ipole **I**nvestigations) in March of 2013. During the winter shutdown 2013, the vacuum chamber will be supplemented with the electrodes and the necessary feedthroughs. A dedicated week of beamtime in February 2014 is planned for final commissioning and calibration of the whole system.

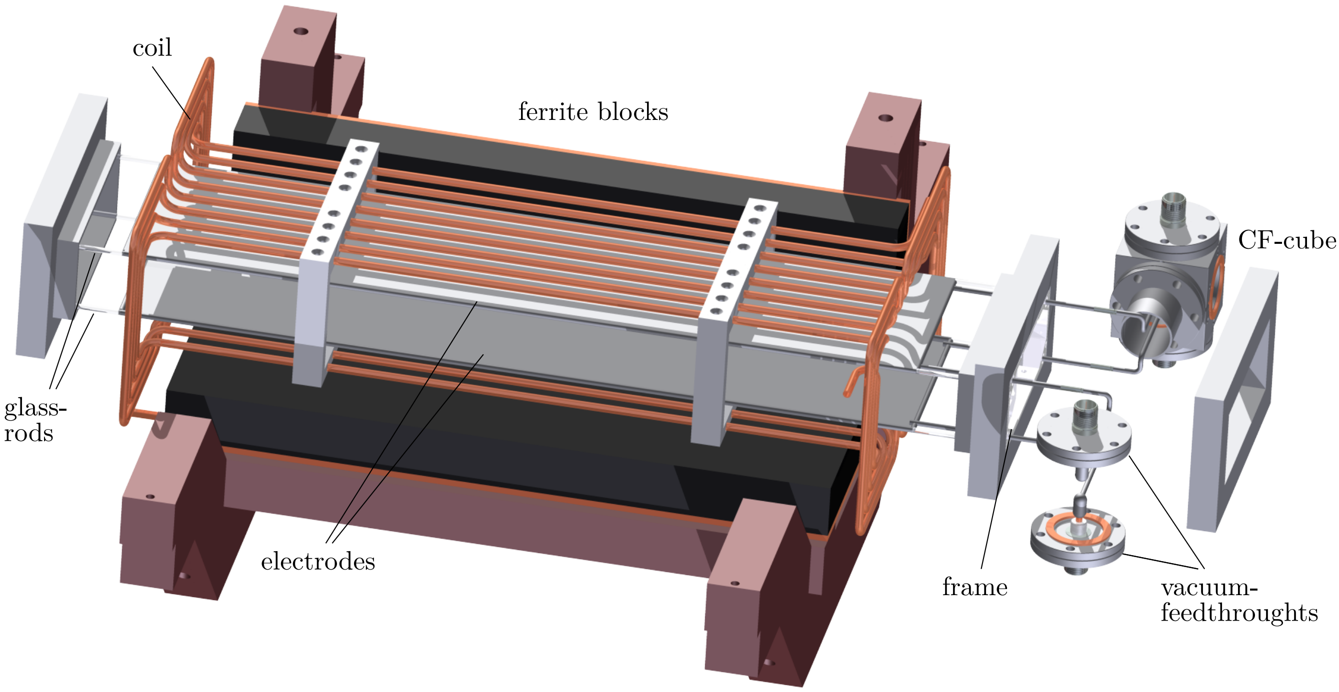

Figure 3: A view inside the RF-E-B-Dipole.